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Predator-Prey Relations Between *Martes flavigula* and Pheasants in the Taktsang-Bumdra Region of Bhutan

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Abstract

Camera-trapping research on predator-prey relationships often focuses on the roles of apex species, leaving mesopredators underrepresented in the research. This study aimed to fill this knowledge gap by studying the yellow-throated marten (*Martes flavigula*), a species native to the Bhutan Himalayas, and its predatory interactions with pheasants such as the Himalayan monal (*Lophophorus impejanus*), kalij pheasant (*Lophura leucomelanos*), blood pheasant (*Ithaginis cruentus*), and satyr tragopan (*Tragopan satyra*), examining how populations of martens and pheasants relate to each other across elevation gradients, habitat type, proximity to human settlements, and time of day. To understand this relationship, we collected camera traps and environmental data from 30 sites within the Taktsang-Bumdra region of the Paro Valley. Kruskal-Wallis and chi-squared tests were run on the relationships between yellow-throated martens and pheasants, both as individual pheasant species and using pheasants as a group. GIS was used to create graphs and visual models of the data, allowing for the interpolation of species ranges and providing valuable insights into the efficacy of future conservation efforts. The results indicate urban areas have less of an effect on several species of pheasant than expected, and agricultural sites attract one species of pheasant while deterring another. There is a difference in marten and pheasant habitat preferences, with all species of pheasants preferring mixed conifers overwhelmingly, while martens were divided between mixed conifers and blue pine forests. Both martens and pheasants were most active in the afternoon, co-occurring at similar times temporally, ultimately meaning pheasant populations are not entirely dependent on yellow-throated marten predation in the Taktsang-Bumdra region, but marten likely have a large effect. The results will increase understanding of population dynamics between the four studied pheasant species and yellow-throated martens. They will give insight into potential research on the population dynamics of Bhutan pheasants and other mesopredators.

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Keywords
Yellow-throated Marten (*Martes flavigula)*, Pheasents, Predator-Prey Dynamics, Taktsang-Bermuda

1 Introduction

1.1 The Mesopredator

Globally, large carnivorous predators play a key role in maintaining the structure and function of ecosystems. Apex species, such as tigers, have substantial top-down effects and are often studied due to their flagship status (Tambling et al., 2018). While less commonly focused on, mesopredators—which are mid-sized omnivorous species—are also important intermediaries in regulating their habitats. Mesopredators are unique in that they are capable of living closer to human populations and in denser numbers compared to larger predators, allowing for unique prey population management strategies (Tambling et al., 2018). Bhutan has several mesopredators, including, but not limited to, *Vulpes vulpes*, *Mustella sibirica*, *Felis marmorata*, and *Martes flavigula* (Wangchuk et al., 2004).

Until this point, most research on mesopredator ecosystem interactions has been on the mesopredator release hypothesis, which defines changes in mesopredator behavior, abundance, and/or distribution as a result of a decrease in apex predator distribution and/or abundance (Prugh et al., 2009). Though this research is important, little research has been done on relationships between mesopredators and their prey, particularly in areas where the apex predators are sparse or nonexistent. The aim of this research is to bridge this knowledge gap.

1.2 Martens & Pheasants: The Mesopredator-Prey Relationship

The yellow-throated marten is found throughout Bhutan, as well as many other countries throughout East Asia. Like other mesopredators in this region, they live around elevations of 2500 m (Basnet & Rai, 2020; Dutta et al., 2022). They often shelter in crevices formed by rock outcrops or within coniferous and broadleaf forests. Temporally, martens were found to be diurnal in undisturbed forests, appearing most often in the afternoon. Yellow-throated martens are known to feed on the fruits and nectar of Rhododendrons and *Bombax ceiba*, respectively, but primarily prey on smaller ungulates, primates, rodents, reptiles, and birds such as pheasants (Basnet & Rai, 2020; Dutta et al., 2022).

Several species of pheasants also populate Bhutan's Himalayas, such as the Himalayan monal, kalij pheasant, blood pheasant, and the satyr tragopan. Although different species, these pheasants all typically feed on leaf litter, seeds, and insects (McGowan et al., 2020a, 2020b, 2020c; Namgyel et al., 2024; Norbu et al., 2013; Saba et al., 2024; Zhao et al., 2025). They have all been found in coniferous and broadleaf forests, especially those with dense bamboo understories (Basnet & Rai, 2020; Dutta et al., 2022; McGowan et al., 2020a, 2020b, 2020c; Saba et al., 2024). Some species, such as the blood pheasant, can be found at higher elevations in the sub-alpine scrub environment

(Soldatini et al., 2010). These pheasant species typically make their nests in depressions of the ground, among bushes and grasses (Basnet & Rai, 2020; Dutta et al., 2022; McGowan et al., 2020a, 2020b, 2020c; Saba et al., 2024). However, despite occupying a wide range of elevation zones and biomes, pheasants have limited dispersal ability, and therefore, the impact of habitat degradation may be more pronounced (Zhao et al., 2025). Related to dispersal, satyr tragopan is known to migrate altitudinally, either across multiple mountain ridges or to higher elevations (Norbu et al., 2013). Twenty percent of pheasant species worldwide already face the threat of extinction due to habitat loss, poaching, and climate change (Zhao et al., 2025). Therefore, building a stronger understanding of the relative spatial and temporal interactions between pheasants and martens will be important for understanding how to conserve pheasant species.

1.3 Spatial-Temporal Relationships between Pheasants and *Martes flavigula*

Little is known about the spatial and temporal relationships between martens and pheasants in the Himalayas, and particularly in Bhutan. But the relationship between pheasants and the Asiatic golden cat, another common mesopredator, has been studied, giving us some insight into what the relationship between martens and pheasants could look like. Research on the occupancy and activity patterns between terrestrial pheasants and the Asiatic golden cat was done in the Phrumsengla National Park in Central Bhutan (Namgyel et al., 2024). Namgyel et al. (2024) found that pheasants were active between dawn and dusk, and there was a negligible predator-prey correlation between these species, despite co-occurring across broadleaf through subalpine forests. These habitats, including alpine scrub and conifer forests, are typical habitats for pheasants in East Asia. Martens also co-occur across these regions (Basnet & Rai, 2020; Dutta et al., 2022).

This study seeks to understand the spatial and temporal overlap between marten and pheasant species. Examining how populations of martens and pheasants relate to each other across elevation gradients, habitat type, proximity to human settlements, and time of day.

1.4 Research Questions

Given current literature and knowledge about pheasant and marten ecology and interactions, we can formulate two main research questions: 1) how do the habitat types of pheasants and martens overlap due to marten predation of pheasants? 2) how do marten and pheasant proximity to human settlements impact the frequency and time of interactions between these species? When surveyed farther from human settlements, pheasants and martens may occupy similar temporal niches, and we examine how that will affect both pheasant and marten populations—as standalones and in relation to one another.

2 Methods

2.1 Study Area

Our data was collected from the Taktsang-Bumdra region near Paro Valley, Bhutan (Figure.1). This region is significant to our study as it encompasses a wide range of elevations and habitats, extending from 2300 to above 4000 meters above sea level, with multiple types of canopy cover. Specifically, the region includes many cool-temperate forests, open space or grasslands, and rocky scrub

lands of the subalpine and alpine zones. It is part of the Himalayan biodiversity hotspot and contains the yellow-throated marten and a variety of pheasant species (Chettri et al., 2010). It is also relevant to note that lower elevations experience significant and ubiquitous human disturbance due to the sprawling footprint of Paro Town. Higher elevations are largely remote, with the main sources of human activity being monasteries and the Bumdra basecamp. And even within areas of higher human activity, Bhutan has still maintained around 60% of its forest cover overall across the last several decades (Feuerbacher, 2021).

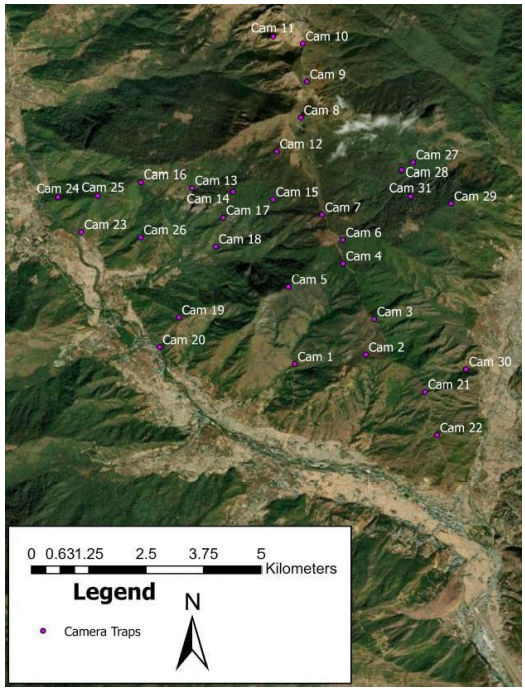

Figure 1 *Map of Taktsang-Bumdra region, showing an aerial view of ridgelines and trees, including 30 camera traps used to collect data on pheasants and martens for this study.*

2.2 Camera Trapping

Data was collected from 32 Reconyx RapidFire cameras (Karanth & Nichols, 2017). Of these 32, only 30 were included for analysis due to errors with other cameras. The cameras observed 134 yellow-throated martens and 114 total pheasants. The cameras were placed in a variety of habitat types and on trails ranging from game to the main human trail. They were attached to posts or trees using nylon straps and angled to face the trail. The cameras include night vision capabilities when low light levels are detected and take three photos whenever movement or a change in heat is detected in front of the camera. The cameras were active from November 2024 to mid-April 2025 and housed the images on SD cards capable of storing between 16 and 32 GB.

At each camera site, environmental variables including elevation, aspect, slope, percent of canopy cover, ground cover, visibility around the camera, trail type, distance from nearest human settlement and agricultural land, signs of human disturbances, and wildlife signs were collected and recorded via the Epicollect5 app. Camera images were then sorted into folders by species, and R Studio was used to rename images and remove duplicate image name.

2.3 Data Analysis

QGIS, ArcGIS, and R Studio were utilized to conduct statistical tests. GIS was used in combination with the Epicollect5 data and Digital Elevation Models (DEMs) from the NASA EarthData system to produce accurate values for how far each camera trap was from urban and agricultural areas (Dataset: ©JAXA/METI ALOS PALSAR L1). All pheasants were sometimes generalized into a larger group because this increases the ability to visualize the spatial overlap between martens and pheasants, whereas the connection would have been smaller on maps created by looking at the relationship between martens and individual pheasant species. They can be

generalized because they are all large birds preyed upon by mesopredators occupying similar ecological niches (Norbu et al., 2013; McGowan et al., 2020a, 2020b, 2020c; Saba et al., 2024; Zhang et al., 2022; Zhao et al., 2025).

To analyze the data in terms of temporal, habitat, altitudinal, distance to settlement, and activity pattern, and distance to settlement correlation, R Studio was used to run chi-square and Kruskal-Wallis tests. In order to determine activity patterns, the number of camera trap images captured using night vision was counted as nocturnal, and the number of default photos was counted as diurnal. Another chi-square test was used to analyze the habitat correlation between martens and pheasants, and the habitat types were recorded in Epicollect5. For the rest of the correlations, a Kruskal-Wallis test was performed due to the number of variables, non-Gaussian distributions, and unequal variance between groups. Additional graphs were made in R Studio to help highlight these habitat, temporal, and spatial differences.

3 Results

3.1 Proximity to Human Settlement

A Kruskal-Wallis test was used to compare the 4 species pheasants and martens proximity to urban and agricultural areas. Significance was found for some pheasants, but not for the marten. With regards to distance to agricultural settlements, blood pheasants and kalij pheasants were found to have significant data (Table 1; Figure. 3). Kalij pheasants were seen relatively near agricultural areas with an average distance of 576 m, whereas blood pheasants were seen much farther (1665 m). Looking at urban areas, blood pheasants, the Himalayan monal, and satyr tragopan had significant data with distances of 391 m, 476 m, and 922 m respectively. Blood pheasants were found near urban areas while being seen farther from agricultural areas. The satyr tragopan was found far from urban areas.

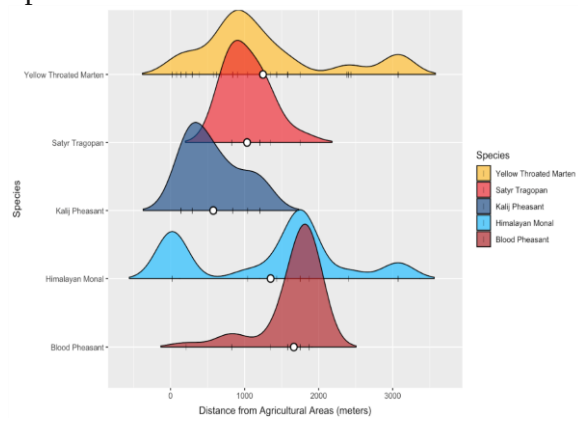

Figure 2 Kalij pheasants are observed nearer to agricultural settlements than blood pheasants. *The individual animal occurrences (black tick marks). Average of all occurrences (white circles). Representing the distribution of pheasants and martens distance from agricultural areas. Kalij pheasants were seen near to agricultural settlements (576 m), while blood pheasants were seen very far (1665 m) (Table 1.)*

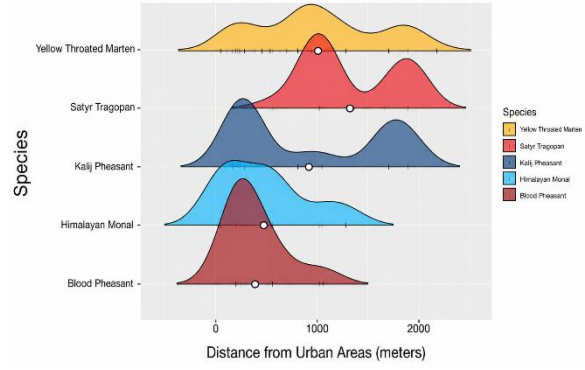

Figure 3 Urban areas have little effect on the blood pheasant and Himalayan monal *. The individual occurrences (black tick marks). Average of all occurrences (white circles). Representing the distribution of pheasants and martens distance from urban areas. Blood pheasants and the Himalayan monal were seen near urban areas (391 m, 476 m), whereas the satyr tragopan was seen farther (922 m) (Table 1.).*

Table 1 Distance to Urban and Agricultural areas of Pheasants and the Yellow-Throated Marten. *Depicting the p-values for phesants and the average proximity of pheasents and martens from agricultural and urban areas. The bolded numbers represent statistically significant results.*

		Species					
		All pheasants	Blood pheasant	Himalayan monal	Kalij pheasant	Satyr tragopan	Yellow-throated marten
Agriculture	p-value	0.7498	**1.07E-05**	0.7498	**1.14E-06**	0.3846	N/A
	Proximity (m)	1128	1665	1351	576	1032	1248
Urban	p-value	**0.0009623**	**3.77E-08**	**0.0009623**	0.5058	**0.007424**	.2761
	Proximity (m)	740	391	476	922	1325	1014

3.2 Habitat Correlation

From pheasant and marten habitat occurrences, habitat overlap between the pheasant species and martens was compared using chi-squared tests (Figure. 4; Table 2). All chi-squared values were high, and all p-values were low, meaning that the null hypothesis can be rejected. This means martens and pheasants had correlation with habitats. Blood pheasants and satyr tragopan were found almost only in mixed conifer forests. Himalayan monals were found in every habitat type except the rhododendron forest. Kalij pheasants were found in blue pine forests and mixed conifer forests. Martens were found mostly in blue pine and mixed conifer forests. This shows there is habitat overlap between martens and all 4 pheasant species.

Table 2 P-values and chi-squared of 4 pheasant species. *Depicting the p-values and chi-squared for pheasants relationship to habitats they were observed in.*

	Species			
	Blood pheasant	Himalayan monal	Kalij pheasant	Satyr tragopan
p-value	**2.2E-16**	**2.2E-16**	**2.2E-16**	**2.2E-16**
chi-squared	**210.59**	**134.9**	**166.42**	**177.25**

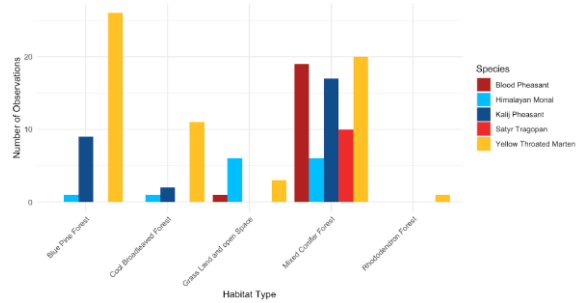

Figure 4 Martens are found in blue pine and mixed conifer forests, while pheasants are common only in mixed conifer forests. *Individual number of observations of each species of pheasant and the yellow-throated marten per habitat type in a bar graph. Total number of cameras per habitable type: blue pine (5), cool broadleaf (3), grassland and open space (2), mixed conifer (12), rhododendron (1). Yellow throated martens were found primarily in blue pine forests and mixed conifer forests. All pheasants were mostly seen in mixed conifer forests.*

3.3 Temporal Correlation

All the pheasant species and the yellow-throated marten were observed to co-occur at the same times of day (Figure. 5; i.e., all species are broadly crepuscular/diurnal). Using a Kruskal-Wallis test, the marten and Himalayan monal temporal co-occurrences were statistically insignificant, while the other 3 pheasants were found to have statistically significant overlaps with the marten. Meaning kalij pheasant, blood pheasant, and satyr tragopan appear at different average times of day, with a large overlap between the ranges of the martens and all 3 pheasant species. These 3 pheasants' mean time of observation was all within 4 hours of the marten.

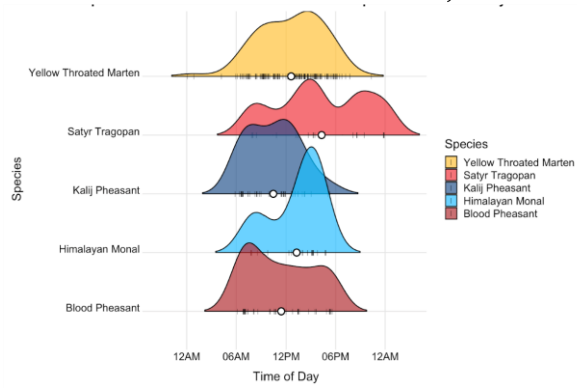

Figure 5 Martens and pheasants have a temporal correlation within 4 hours*. Depicting a ridgeline plot for the various species in the Taktsang-Bumdra region. Each individual observation (black tick marks). The average time of day that each species was observed (white dots). All species of pheasants were diurnal and had overlapping ranges of observation with the yellow throated marten.*

Table 3 P-values of temporal co-occurrence between marten and 4 pheasant species. *Depicting the p-values for pheasants temporal co-occurrence with martens.*

	Species			
	Blood pheasant	Himalayan monal	Kalij pheasant	Satyr tragopan
p-value	**.05726**	.1093	**.0004624**	**.01029**

3.4 Elevation Gradient

Significance was found 4 out of 5 times using a Kruskal-Wallis test when using elevation as a covariate. The relationship between martens and kalij pheasants, Himalayan monals, blood pheasants, and all pheasants as a group was significant. Blood, kalij pheasants, and Himalayan monals were all observed at least 150 m above and below martens (Figure. 6). Overall martens had a large overlap with pheasants, overlapping over a significant portion of the blood pheasants range, and all of the kalij pheasant, and Himalayan monals range.

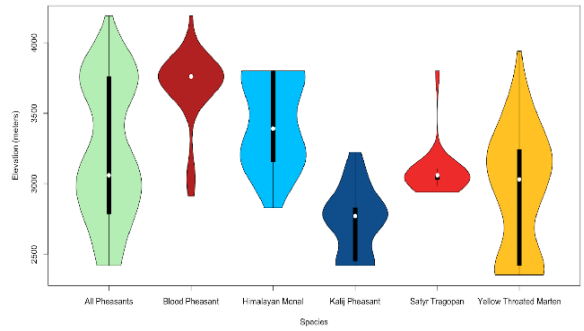

Figure 6 Martens were observed near the same elevation as pheasants. *Relative abundance at each elevation (width of each plot shape), 50% of observations (thick black bar), the rest of the data points without outliers (thin black line), and mean elevation (white dot) for each individual pheasant species, all pheasants together, and the yellow-throated marten in a violin plot. Martens had overlapping ranges with all pheasants which were found to be significant with regards to elevation*

Table 4 P-values of elevation co-occurrence between marten and 4 pheasant species. *Depicting the p-values for pheasants elevational co-occurrence with martens.*

		Species			
	All pheasants	Blood pheasant	Himalayan monal	Kalij pheasant	Satyr tragopan
p-value	**.00004575**	**1.074E-15**	**.00004575**	**.00366**	.2768

4 Discussion

4.1 Spatial Correlation/Proximity to Human Settlement

Significance was seen for kalij and blood pheasants when distance from agricultural settlements was tested. Kalij pheasants were observed near to agricultural settlements, while blood pheasants were observed much farther. These results indicate that the number of blood pheasants and kalij pheasants is correlated with proximity to agricultural settlements. Several possible explanations for

why kalij pheasants would be found near agriculture include possible grazing on crops of agricultural settlements (especially those used to feed livestock), a tolerance for human activity, reduced competition from other animals which lack tolerance for human disturbance, the exploitation of edge habitats, or the possibility that human disturbance decreases the likelihood of predators in the area (Bista et al., 2020; Jameel et al., 2022; Jameel et al., 2024). A possible explanation for the behavior of the blood pheasants is the livestock near agricultural settlements may be ruining the understory vegetation with overgrazing, preventing blood pheasants from finding good habitat near agricultural settlements (Bista et al., 2020; Jameel et al., 2022; Jameel et al., 2024). A future study could examine the necessity of understory vegetation for blood pheasants versus kalij pheasants.

When proximity to urban areas was analyzed. The quantity of all pheasants but the kalij pheasant was found to be correlated to the proximity to urban areas (Table 1). The expectation is that all pheasants would be far from urban settlements due to associated forest degradation (Namgyel, 2024). But the results show that blood pheasants and the Himalayan monal exist near urban settlements. It is possible that the high forest cover in Bhutan, which has remained stable, covering around 60% of the country over the last several decades, provides enough habitat for these species (Feuerbacher, 2021). Whereas the satyr tragopan may be highly sensitive to human disturbance due to its high distance from urban areas.

4.2 Habitat Correlation

Yellow-throated martens were primarily observed in mixed conifer and blue pine environments, this could indicate a preference (Figure 4). The various pheasant species showed an overwhelming correlation with mixed conifers, but were also observed in other regions to a lesser degree (Figure. 4). This could indicate a preference for mixed conifers among the pheasant species. Our chi-squared test accounted for the fact that the majority of our cameras were located in mixed conifer forests and produced results indicating that the overall preference for mixed conifers was not due to random chance. For species like the Himalayan monal, which were found at equal rates in multiple habitats, we can infer that they prefer both mixed conifer forests and grassland/open space. These results correlate with our original understanding that Bhutan's pheasant species prefer coniferous forests, but they were largely absent from cool broadleaved environments and locations with a thick bamboo understory, where we had originally thought they would be due to previous studies (Basnet & Rai, 2020; Dutta et al., 2022; McGowan et al., 2020a, 2020b, 2020c; Saba et al., 2024). Pheasant species were likely observed there in low numbers because only 3 of the 30 cameras were in cool broadleaf environments.

Overall, the abundance of yellow-throated martens (n=134) and the total number of pheasants (n=114) were relatively similar, suggesting some level of ecological balance. Martens and pheasants overlapped significantly in the mixed conifer forests, suggesting that this is where most of the predator-prey interactions could occur. Interestingly, the martens were most abundant in the blue pine forest, where overall pheasant numbers were low, with the exception of the kalij pheasant. This suggests its possible while pheasants are likely a large part of the martens diet, they feed on other species such as smaller ungulates, primates, rodents, and reptiles (Basnet & Rai, 2020; Dutta et al., 2022).

4.3 Temporal Correlation

All pheasants were found to be active throughout the day from late morning to late afternoon on average, while both the yellow-throated marten and all pheasants together were primarily active around noon (Figure. 5). All pheasant species were broadly diurnal, with the most frequent temporal occurrences happening near midday, which is supported by previous research on the birds (McGowan et al., 2020a, 2020b, 2020c; Namgyel et al., 2024; Norbu et al., 2013; Saba et al., 2024; Zhao et al., 2025). The yellow-throated marten also trended towards diurnal temporal correlation as most sightings were around midday, aligning with previous research (Basnet & Rai, 2020; Dutta et al., 2022). Meaning it is possible these pheasants make up some of the main prey of martens due to their similar observation times.

The satyr tragopan had the latest average time of activity, with many sightings after sunset. The satyr tragopan also had a high p-value when compared with the yellow-throated marten, so these results may be due to chance. And even though observations were spread out throughout the day and early night, the satyr tragopan was still found to be broadly diurnal.

All pheasant species except for the Himalayan monal had a statistically significant relationship with the yellow-throated marten for temporal co-occurrence. This could be attributed to the predator-prey relationship between the pheasants and the marten. Pheasants are active during the day and hunt for food in groups, so martens can feasibly hunt them before they hide and rest for the night (Zhang et al., 2022).

4.4 Altitudinal Gradient

Martens were found to exist at average lower elevations than all pheasants except for the kalij pheasants (Figure. 6). However, the martens' range overlapped with the kalij pheasant and Himalayan monal entirely, while partially overlapping with the blood pheasants range. These findings support previous research, which has shown that martens tend to live around 2500 meters above sea level, while the blood pheasant and Himalayan monal live higher, at around 3300 meters (Dutta et al., 2022; Zhao et al., 2025). However, even with a higher average range there are still interactions between these species of pheasant and martens. Satyr tragopan, however, were found to be statistically insignificant with their altitudinal relationship to martens.

The overlap in range of the marten and Himalayan monal, blood pheasant, and kalij pheasant suggests that martens in the Taktsang-Bumdra region feed on pheasants as a large part of their diet (Basnet & Rai, 2020; Dutta et al., 2022; Zhao et al., 2025). Pheasants usually migrate to higher elevations in warmer months to avoid predators (Zhao et al., 2025). This explains the higher relative elevation of the Himalayan monal and blood pheasant. The lower observed elevation of Kalij pheasants is likely due to the seasonal migration because the study period was during the winter months (November 2024 - April 2025). However, Kalij pheasants have been known to occupy lower elevations when needed and could be living lower to avoid occupying the same ecological niche that other pheasants in the Taktsang-Bumdra region do (Saba et al., 2024).

5 Conclusions

Ultimately, our confined data set—November 2024 to April 2025—could have posed limitations to our study. This more restricted sample size may have reduced our statistical power and increased uncertainty in our results, so we believe this is a study that can be continually built upon and expanded. It's also notable that our samples are coming from a relatively small area in a country with unique agricultural and urban settings (Feuerbacher, 2021). With many settlements in Bhutan existing within Bhutan's national parks in heavily forested areas, agricultural and urban settlements may be unlike those of other countries with the same wildlife.

Our research suggests several things about the relationship between martens, pheasants and their environment. Blood pheasants may be attracted to urban areas, while deterred from agricultural ones. While the satyr tragopan is deterred from urban areas. Martens and pheasants co-occur in conifer forests, while martens also occur in high numbers in blue-pine forests. Martens and pheasants were both seen to be diurnal with large times of overlap between martens and pheasant species. Martens were also found to have an overlap in elevation range with blood pheasants, Himalayan monals, and kalij pheasants. Overall, this suggests that pheasants make up a large part of martens diets, but due to the high amount of martens found in blue pine forests and the relative lack of pheasants in this habitat, martens likely feed on a variety of other prey.

Since pheasants globally are becoming increasingly threatened due to habitat loss, poaching, and climate change, this research is important for gaining a basic understanding of how pheasants and one of their predators, the yellow-throated marten, interact and behave (Zhao et al., 2025). With this understanding, there may be better-informed conservation practices implemented for pheasants. Additionally, with more baseline research on marten-pheasant relationships, this study could spark inspiration for more intensive research done on predator and prey relations in Bhutan, especially with the less studied mesopredators.

Acknowledgements

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Appendix

Table 5 *Depicting the p-values from the Kruskal-wallis test for species and elevation, distance from agriculture, distance from urban, and time. Insignificant results (red). Significant results (white)*

Kruskal				
	Elevation	DistanceFromAg	DistanceFromUrb	Time
Species Type				
Pheasant	4.58E-05	0.7498	0.0009623	0.1093
BloodPheasant	1.07E-15	1.07E-05	3.77E-08	0.05726
HimalayanMona	4.58E-05	0.7498	0.0009623	0.1093
Satyr Tragopan	0.2768	0.3846	0.007424	0.01029
KalijPheasant	0.00366	1.14E-06	0.5058	0.0004624

Statistical Tests Code

R Code Package Installation

Violin Plot Code

Ridgeline Code:

- Agriculture
- Urban
- Temporal

Habitat Type Code

Predator-Prey Relations Between Martes flavigula and Pheasants in the Taktsang-Bumdra Region of Bhutan

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